FACTS

FOR ENVIRONMENTAL STUDIES

Ontario

Ministry of the Environment

Hon. George A. Kerr, Q.C., Minister

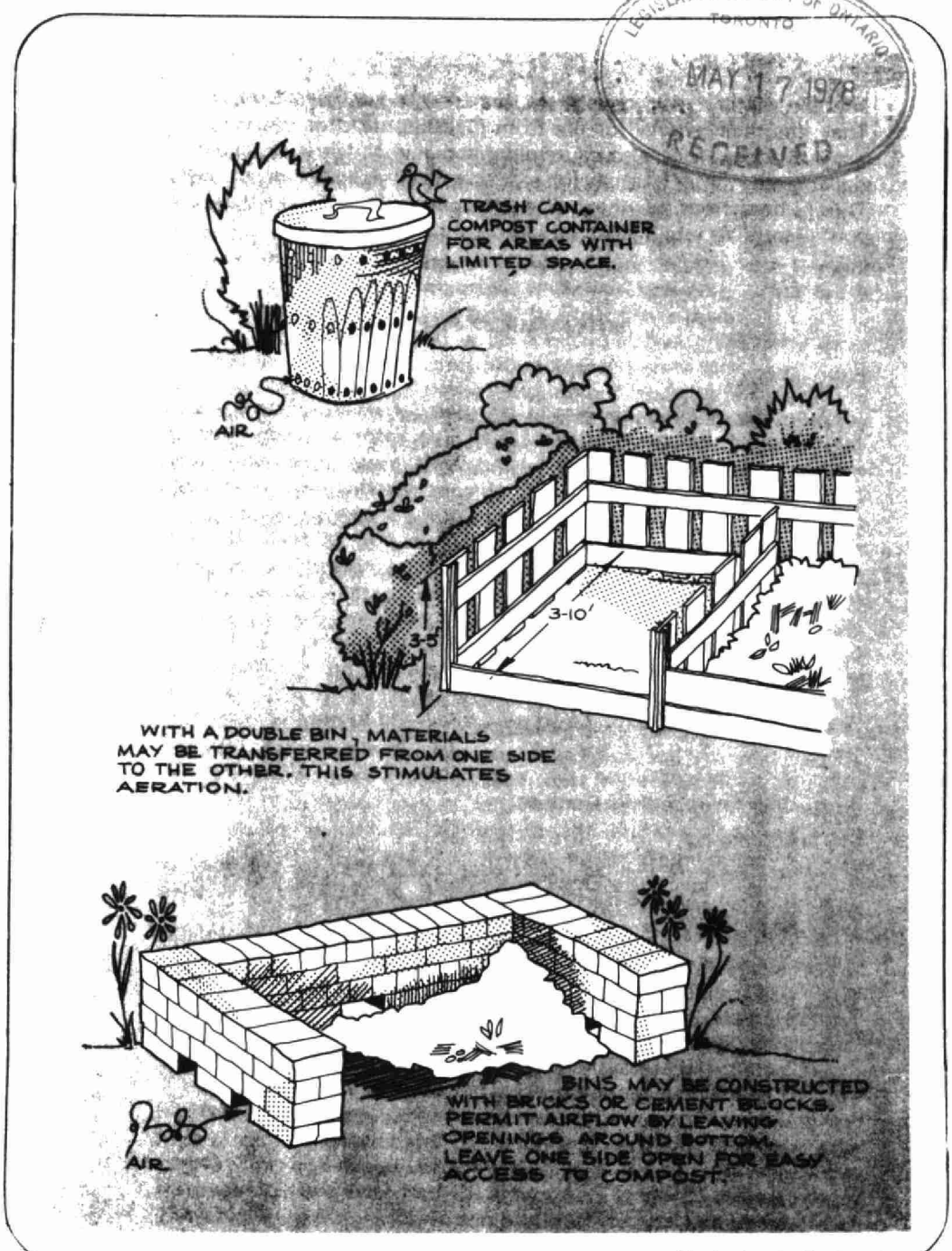
Everett Biggs, Deputy Minister

ECOLOGY OF COMPOST

A Public Involvement Project

OUR SOLID WASTE PROBLEM

Man has always produced solid wastes! Today, however, waste production is greater since there are many more people. More garbage is produced and more discarded products accumulate from our way of life. The "no deposit-no return" practice is convenient for a moment but "throw-away" objects and convenience packaging materials finally become a large part of our solid waste problem. They accumulate mainly because they are not easily "broken down" or degraded.



Illustrations by Dr. Dindal.

Other sources of solid waste are meat and vegetable materials from our kitchens. Garbage ground up in kitchen disposal units drains away and is quickly forgotten because we as individuals no longer deal with it directly. Again, however, disposed items may haunt us as a community when they reappear at overburdened sewage disposal facilities, or they may be expelled untreated into our lakes or streams as organic pollutants. Also, a variety of unused natural materials are discarded from our lawns, yards and gardens. These domestic organic wastes of kitchen and lawn trimmings comprise 18 to 30 percent of our nation's solid waste materials.

Cities and towns everywhere are trying to solve their solid waste problem. Proper disposal or utilization of solid wastes will cost more money. And, as we know, governmental budgets are strained to their limits. What is the solution?

Take some individual action! Assist in a small way by using household wastes for other purposes. Follow the recycle-reuse principle which occurs naturally. In fields and forests, plants fall to the ground, decay and release vital nutrients that may be used by other plants and even animals. Also, animals die, decay and chemical substances in their bodies are reused and recycled as nutrients in the soil system.

This same recycle-reuse pattern can be employed with your household wastes. You can reuse garbage and lawn trimmings by recycling them back into your land. Your soil will benefit and your involvement can aid in a small way in solving this major solid waste problem.

ENHANCE YOUR BACKYARD — AN ECOLOGICAL COMMUNITY

Nowadays people are becoming aware of how all living organisms (plants, animals and man) are interrelated to the physical and chemical environment in which they live. Study of these relationships of organisms to the environment is known as **ecology** — a word coined by a biologist in 1866. Today, ecology is a popular word which has taken on various meanings. However, in this booklet the original definition accepted by ecologists is used.

Living organisms found in an area are known collectively as an **ecological community.** Look around your home. What organisms make up the ecological community in your backyard? Probably you did not include a common but tiny community or **microcommunity** existing within the soil itself. Organisms in the soil microcommunity are so dynamic that some people speak of soil as being "alive." You can enhance this biological activity with the use of household wastes which will increase the organic matter in soil.

Organic matter is a vital part of soil. This material must be present for the microcommunity to function properly. Also, organic matter combines physically and chemically with minerals in the soil making an ideal crumbly structure. This kind of soil structure results in an increase of air spaces and water holding properties. Increased water holding capacities in turn permit the soil and plants to withstand drought conditions much better. But so many of man's activities disturb the functions of organic matter in soil. For example, construction operations often cause layers of organic matter to be buried deeply below the surface. Raw mineral soil or subsoil is exposed, and advantages of organic matter are lost. Until the organic matter is renewed, plants grow with difficulty. If you live in a new housing development and have this kind of problem, start a household waste recycling project to improve your soil.

The major thrust of your recycle-reuse project should be composting. Composting consists of mixing your household wastes together in the proper way and allowing them to decay. Resulting mixtures or composts are worked into soil around shrubs, in gardens or potted plants in the same way as organic matter is incorporated naturally in forests and fields. For years organic gardeners have used this method with much success.

The main force behind successful composting is proper decomposition. Most chemical decomposition occurs naturally by numerous microorganisms (bacteria, molds or fungi, actinomycetes and protozoa). Tiny invertebrate animals such as mites, millipedes, insects, sowbugs, earthworms and snails are primary agents of physical decay. They break up waste debris and transport microorganisms from one

site to another. All these organisms are known as **decomposers.** They get their energy for life from digesting dead or decaying organic residues. They also cause plant and animal debris to be finely decomposed until it is no longer recognized as waste or garbage. Thus, interactions of the soil microcommunity will change your waste materials into a valuable soil constituent.

THE COMPOST PILE

Construction

Select an inconspicuous site on your lot where organic debris may be piled. Perhaps you can use an area behind a hedge row or garage or beside the garden. A heap, a pit, a variety of enclosures or open bins may be used for compost production. Use a large garbage can, a wooden box or a barrel if your space is limited. If space is no problem, the pile may vary from 3 to 10 feet wide and have an optimum height of 3 to 5 feet. Any convenient length is suitable. Also, be sure to make openings in containers for proper aeration. Where winters are extreme and summers dry, make compost in 12- to 14-inch deep pits in the soil. Compost in pits stays warmer in winter and remains damp in the summer. Finally, if you use a bin, no floor is needed, and it should have one end with removable sides for easy access in adding and turning organic matter.

Necessities for Successful Compost

Energy source

Waste residues are the major source of energy for decomposer organisms. Any of the following natural residues can be composted with the proper care:

- kitchen garbage
  - vegetable and fruit peelings
  - coffee grounds
  - egg shells
  - clam and oyster shells
  - peanut and nut shells
- leaves
- grass clippings
- weeds
- garden residues
- straw and hay
- sawdust
- manure
- pet wastes
- newspaper
- soybean meal
- cottonseed meal
- bone meal
- dried blood
- sewage sludge
- barbecue grill residues

Rates of decomposition will be increased if these items are ground up before using them. Rotary mowers can be used for shredding leaves and plant parts, especially if equipped with a mulcher. Cornstalks, hay, weeds and straw should be no longer than 6 inches in length. Newspaper should be cut into small shreds or pieces. Some people even chop or grind up garbage before adding it to the pile. Grinding increases the surface area and provides more space for decomposers to feed and grow.

Many methods for adding materials to compost heaps have been used. Some people add materials whenever it becomes available. Using this method you must mix different residues thoroughly. Do not add any one substance too thickly. For instance, sawdust and other finely divided materials easily become matted and prevent adequate circulation of air. Other people organize layers of debris as illustrated. In either case the pile must be turned and mixed periodically so that decomposition is complete. Wastes that are not decayed should be worked toward the center. The temperature within the pile indicates when the heap should be turned. Thrust a thermometer into the center of the pile and turn the residues when the temperature is near 150°F. Usually when ground or shredded materials are used, this temperature is reached every 3-4 days. Larger pieces of debris require more time, 3 to 6 weeks, before they should be turned.

C:N ratio and nutrients

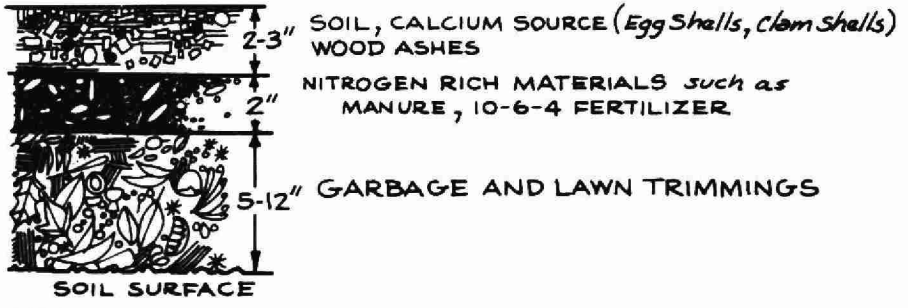
Decomposers require not only a carbon (C) source for energy but also a source of nitrogen (N) in order to multiply and completely decay waste materials. An ideal C:N ratio for most soil microorganisms ranges from 15:1 to 30:1. That is, for every 15 to 30 parts of carbon 1 part nitrogen must be present for soil flora and fauna to thrive. Most household wastes that you will use have a carbon-nitrogen content between 30:1 and 40:1. Straw has a C:N ratio of 80:1, while conifer needles and saw dust have higher ratios of 66:1 to 113:1. When ratios are high, nitrogen must be added in some form in order to attain the ideal 15:1 to 30:1 ratio. Organic gardeners use natural sources of nitrogen such as manure and urine (0.5 to 5%N), sewage sludge (1% N), parts of leguminous plants (1.5-4% N), peanut shells (3-4% N), dried blood (10% N) and soybean or cottonseed meal (7% N). The last three items are often available in garden stores. When using leguminous plants (clover, alfalfa, beans) as the nitrogen source, mix one part of them with two to three parts of non-leguminous waste material.

Potassium (K) and phosphorus (P) are also present in small but sufficient amounts in all of the above natural materials. These additional nutrients, potassium and phosphorus, become incorporated in the compost and increase the value as a fertilizer.

Commercial fertilizer is an alternate source of nitrogen. The combination fertilizer, 10-6-4 (N-P-K), has been used successfully in composting. Urea fertilizer as a nitrogen source may be purchased and applied at the rate of 0.3 pound (slightly less than 1/2 cup) per 20 pounds of dry waste material. Ammonium sulfate fertilizer is another nitrogen source. Add it at the rate of 0.7 pound (slightly less than 1 cup) per 20 pounds of dry waste matter. This is especially appropriate for plants requiring acid soils.

The presence or absence of acids (**pH**) in your compost heap is another important ecological factor. Generally a pH range from 6-8 is necessary for optimum microbial decomposition of your organic debris. Many acids are present in organic residues, and it is possible to decrease decomposition by a low pH. Therefore, ground limestone, crushed clam or oyster shells, egg shells, wood ashes, or bone meal may be added to neutralize acidic conditions. For instance, if you use ammonium sulfate as a nitrogen source, add an equal amount of one of the above materials to neutralize the acidity (low pH) related to sulfate. If not neutralized, too much ammonium sulfate will cause the death of earthworm and other important soil invertebrate populations. Urea, conversely, produces slightly basic (high pH) conditions which are more optimal for decay. Incidentally, a good source of wood ashes is the residue from your barbecue grill or fireplace.

ARRANGEMENT OF LAYERS FOR COMPOSTING



REPEAT THIS THREE LAYER SCHEME UNTIL PILE IS 3-5 FEET HIGH.

Moisture requirements

Decomposer organisms require conditions of high moisture, but they cannot withstand being submerged. Here you can observe a vital relationship between organisms and a physical factor — water. Too much water will replace air in the spaces between residues. Consequently, aerobic microflora and fauna will die or become dormant due to lack of oxygen.

Control this problem by sprinkling each layer of waste material with a fine spray of water. But, be careful the debris is not soggy. Frequently debris on the bottom of the heap will get too wet. Reduce such excess moisture by turning the pile. Fresh green wastes like grass cuttings will require little or no additional water. Drying may also be a problem particularly with small heaps. Add water whenever the heap appears too dry — maybe every 2 weeks. Generally, a 50 to 70 percent moisture content in your compost pile is best.

In summary, you must maintain a delicate balance of moisture. If the compost heap is too dry, decomposition will cease; if too wet, nutrients may be lost by leaching and offensive odors will be produced.

Aeration

Organisms that do not need gaseous oxygen are called **anaerobic,** whereas, plants and animals requiring oxygen are known as **aerobic.** Since complete composting is caused by aerobic forms, adequate circulation of air is essential. Proper moisture levels and turning maintain and promote an aerobic micro-environment within the pile. Remember also, to make openings in compost containers or bins for air circulation and drainage. Another method is to stack your organic debris around and on top of wooden poles which are pulled out later providing aeration channels through the heap. The lack of oxygen is usually caused by packed or matted materials and too much water. Anaerobic organisms grow well under these conditions. They produce putrid odors from gases such as ammonia and hydrogen sulphide, and decomposition is incomplete. Obviously, you must minimize the anaerobic state within your compost heap.

Inoculum or "compost starter"

Your compost pile will be naturally inoculated with a variety of necessary decomposer organisms. Spores, eggs and dormant stages (propagules) of decomposers are always present in soil, on surfaces of organic debris and even on household wastes. Packages of compost inoculum are available on the market, but controlled scientific tests show no increased benefits over natural sources.

Heat production

Much heat energy is released by microorganisms as decay occurs. This is a signal the C:N ratio is satisfactory and composting is progressing well. Microorganism populations are growing actively. Organisms that grow best at normal summer temperatures are called **mesophilic** forms. Early decay processes will be caused by mesophilic bacteria and fungi at an optimum temperature range from 77-86°F (25-30°C). As temperatures rise to 112 or 150°F (45-65°C), populations of **thermophilic** (heat loving) bacteria, fungi and actinomycetes begin to increase and take over decomposition. At these high temperatures, population numbers may be more than 10 billion microorganisms per gram of debris. As suggested, the temperature pattern is affected by the size of materials, nitrogen concentration and moisture content.

During this heating period, soil invertebrates will either die, become dormant or migrate away from the heated center. They may move to cooler sites in the periphery of the pile. But, soil animals will again colonize these areas after the heated conditions cease.

Organisms of the Compost Microcommunity

By now, you can appreciate the role of decomposers in composting. Another complexity of this microcommunity is the vital dependence of all organisms upon each other. Organisms exhibit a network of specific feeding habits called a **food web.**

Presence of a carbon and nitrogen source stimulates growth and digestion of wastes by fungi, bacteria and actinomycetes. Cellulose decomposition by these microorganisms occurs soon after the compost pile is established. Fungal mycelia quickly penetrate all parts of the heap. Early fruiting bodies of mesophilic fungi grow on the surface, and later, thermophilic actinomycete colonies may give the surface a grey appearance. At the same time under mesophilic conditions, mites (acarines), millipedes (diplopods), sow bugs (isopods), snails and slugs (gastropods) ingest plant tissues. Soft tissues of decaying plants and animals support growth of round worms (nematodes) and potworms (enchytraeids). Minute flies (dipterans) lay eggs which hatch into larvae that feed on wastes. Earthworms ingest, digest and reshape organic matter. Maximum microorganism growth then results from this perforation and diminution of debris. This group of organisms is called the first level consumers in the decomposer food web. They feed or digest the basic carbon sources that you deposited.

With so much food available, first level consumer populations could continue to increase until the efficiency of the microcommunity would be lost and the delicate balance would be disrupted. As with most natural systems, the compost microcommunity possesses some balancing elements. First level consumers attract and become the food of second level consumers. Other mites and springtails (collembolans) eat fungi. Tiny feather-winged beetles (ptiliids) feed on fungal spores. Nematodes ingest bacteria. Protozoa and rotifers present in water films feed on bacteria and plant particles. Predaceous mites and pseudoscorpions prey upon nematodes, fly larvae, other mites and collembolans. Free-living flatworms (turbellarians) ingest gastropods, earthworms, nematodes and rotifers. Third level consumers such as centipedes (chilopods), rove beetles (staphylinids), ground beetles (carabids) and ants (formicids) prey on second level consumers.

Fecal material from primary decomposers is ingested by other decomposer organisms. Also, fecal pellets are sites for increased microorganism growth. As food items pass down the gut of animals, minute quantities of metabolites accumulate in the excreta. Metabolites in feces provide added nutrition for all types of decomposers.

Finally, after each decomposer dies all the nutrient constituents in its tissues such as nitrogen are again recycled into other organisms.

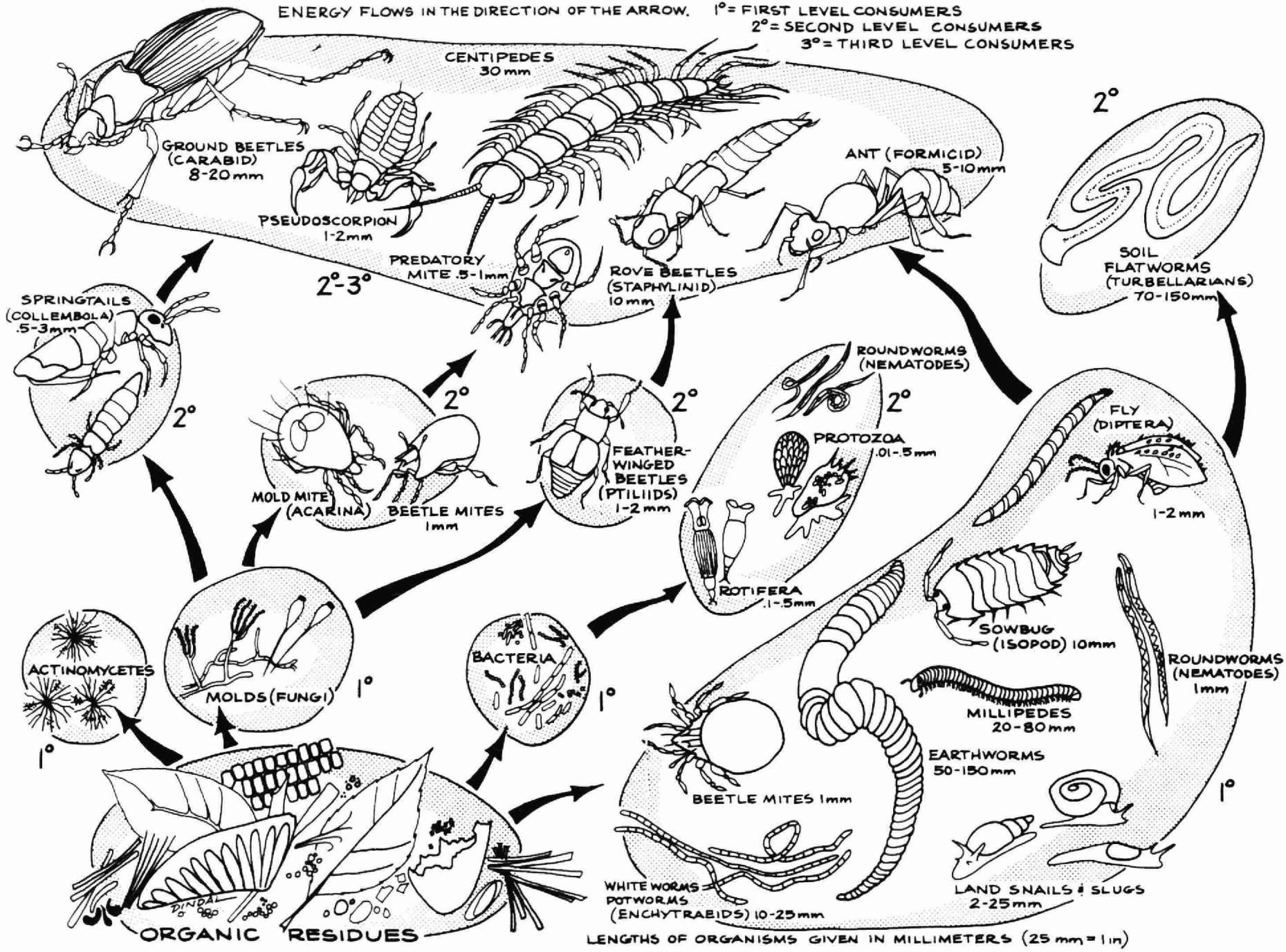
You can observe these detailed functions of this microcommunity by conducting a simple experiment. Enclose a leaf in a plastic mesh bag and place it within the compost pile. Periodically observe it closely. Watch the progress of micro-animals and plants as the leaf becomes skeletonized. Keep a record of types of organisms you see. Their pattern of appearance (or **succession**) and their role in decomposition has been repeated innumerable times in forest soils over thousands of years.

Precautions Against Pests

You have just seen why numerous decomposer plants and animals are necessary in composting. Not all organisms, however, are welcome in your compost pile. Compost heaps will not become pest reservoirs if the pile is made and maintained properly. The nature of the pest problem will depend upon where you live. Consult local community rulings regarding garbage disposal related to pest problems. In urban areas, disturbance by stray dogs and rats should obviously be discouraged. Several methods are effective. Use a minimum of meat scraps or bones. When used, grind or powder them finely. Incorporate the ground material deep within the pile

FOOD WEB OF THE COMPOST PILE

ENERGY FLOWS IN THE DIRECTION OF THE ARROW. 1° = FIRST LEVEL CONSUMERS
2° = SECOND LEVEL CONSUMERS
3° = THIRD LEVEL CONSUMERS



LENGTHS OF ORGANISMS GIVEN IN MILLIMETERS (25 mm = 1 in)

so they are well covered. Secondly, modifications may be built into your compost bin if you anticipate pest problems. Covers or lids can be used providing aeration is sufficient. This may also keep small piles from drying out so quickly.

Plant residues infected with insect pests or plant diseases should not be used. However, some workers have shown that the hot phase of decomposition destroys pests and disease organisms as well as weed seeds. Also, there is evidence that antibiotics are produced by fungi and actinomycetes within decaying vegetable matter. These may act as natural pest control substances. Finally, if a major plant disease or pest is a problem in your area, a formaldehyde solution (formalin) treatment of compost is recommended before using it.

Pesticide applications are not recommended for compost piles. Many are persistent. Fungicides and insecticides disrupt the structure of the microcommunity in various ways. Normal composting processes may not occur and effects cannot be predicted.

Uses of Developed Compost

Compost is ready to use when the temperature within the pile drops back to that of the surrounding air. At that time, it is finely divided, crumbly in your hand and darker in color. It also has a C:N ratio ranging from 10:1 to 20:1.

Developed compost is used as mulch around trees or shrubs or is worked into the soil. Mix thoroughly with soil for gardens, potted plants or new lawns. Application rates depend on the condition of your soil and may vary from 1 to 10 bushels per 250 square feet. It may be applied several times a year or whenever needed.

SUMMARY

As you finally incorporate the compost into the soil, you are truly a part of the ecological community of your area. Waste materials are reused. Organic matter and nutrients are recycled. You have helped alleviate the solid waste problem. You are working in harmony with the living phase of the soil, and valuable decomposer organisms are replenished. Soil is improved. Lawns, flowers, gardens and shrubs should benefit. You have become more closely related to the organisms and physical environment around you.

The content of this fact sheet was taken from the publication Ecology of Compost by D.L. Dindal, with permission of the State University of New York College of Environmental Science and Forestry, Syracuse, New York.